# Sound transmission from the free field to the eardrum

Hammershøi, Dorte; Møller, Henrik

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**Sound transmission from the free field to the eardrum**

D. Hammershøi, H. Møller, *(Acoustics Laboratory, Aalborg University, Fredrik Bajers Vej 7B, DK-9220 Aalborg Ø, Denmark)*

By means of probe microphones, measurements were carried out at various points in the external ear of 12 human subjects. The transmission along the ear canal was investigated, and it was found that the transmission to the eardrum from any of the points within the ear canal was independent of direction of sound incidence. This means that all directional information is included in the sound pressure at the entrance to the ear canal.

A model (first introduced by Møller [1]) was used to split up the sound transmission into three parts: 1) the transmission from the free field to the pressure at the entrance to the blocked ear canal, 2) a pressure division between the radiation impedance seen from the ear canal and the input impedance to the ear canal, and 3) the transmission along the canal. Only the first of these three parts depends on the direction of sound incidence (see Figure 1).

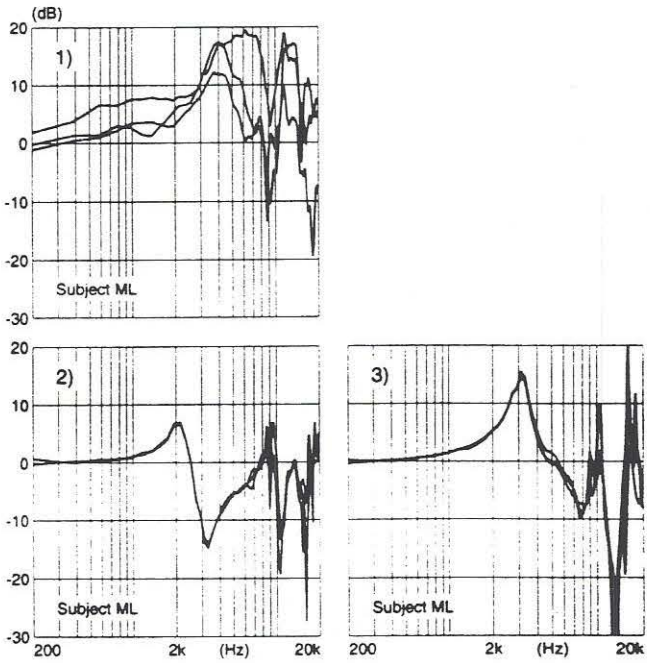


*Figure 1. Example of the three sound transmission elements for left ear of a single subject. The transmission for sound coming from the front, from the left side and from the back are overlaid in each frame.*

The three transmission elements of the model were examined with respect to inter-dependence between the elements, and with respect to inter-individual variation. It was found that characterization of the sound transmission from a free field to the ear canal by means of Head-related Transfer Functions (HRTFs) measured at the entrance to the blocked ear canal offers three important qualities: 1) full spatial information is included, 2) the HRTFs are independent of the remaining transmission to the eardrum, and 3) the HRTFs are least influenced by inter-individual variation.

The investigation is reported in detail in Hammershøi and Møller [2], and discussed in the context of binaural recording and synthesis in Hammershøi [3].

**References**

[1] H. Møller (1992) "Fundamentals of Binaural Technology", Appl. Acoust. 36 171-219.
[2] D. Hammershøi, H. Møller "Sound transmission to and within the human external ear", to be published in J. Acoust. Soc. Am.
[3] D. Hammershøi (1995) "Binaural technique - a method of true 3D sound reproduction", Ph.D. dissertation, Aalborg University, Aalborg, Denmark.